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Systemic Design, from the content to the structure of education: new educational model.

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Abstract: In the 19th century, new discoveries permitted to *pass from the Cartesian mechanism to a holistic view of life*. In the educational field movements as Constructivist Learning and Holistic Education have represented an important contribution to this change of paradigm. In this scenario Systemic Design was born: it aims to imitate Nature in anthropic activities. The educational model used to teach this discipline should follow the holistic approach in order to raise awareness in new generations of conscious and responsible citizens for a sustainable future. Indeed, it is not possible to use a linear model like the current one. The case study used to sustain this thesis is the academic lab 'Open Systems' of the MSc Systemic Design of Politecnico di Torino, composed of four courses that work together (Design, Economy, Engineering, Humanities). The lab is questioning its model aligning it with the specific characteristics of an open living system.

Keywords: holistic approach, education model, systemic design, sustainability, system

1. Introduction

1.1 Higher education

Teaching in higher education contributes effectively to the creation of a new generation of workers and citizens. As stated by OECD, the skills and the competencies for new millennium learners are: creativity, critical thinking, collaboration, productivity, innovation, decision making, communication and leadership (Ananiadou and Claro, 2009). It means dealing with adults and no more children, talking about Andragogy and no more Pedagogy. Theorized by Knowles M.S. in 1980, Andragogy puts the focus on (Kearsley, 2010):

- the involvement of the learner in planning and evaluation;
- the consideration of the precedent experiences (including mistakes) of the learner;

- the discussion of subjects that are relevant for their life or job;
- a problem-centered learning rather than content-oriented

1.2 From linear to systemic vision: effects on education

From the Age of Enlightenment, the western culture was based on the power of reason. Following this principle, the ability to organize the knowledge of the world in a rational way became a principal skill and the different disciplines were developed. Everything was seen as a component of a mechanical machine in which the parts were separated. In this scenario "the task of the teacher was to make clear to the learner the working of this machine and any accommodation to the learner was only to account for different appropriate entry points for different learners"(Hein, 1991). Mechanism guided the western culture until new discoveries in physics - the quantum theory - have permitted to pass from the Cartesian and Newtonian mechanism to a holistic and ecological view of life (Capra, 1996). This was helped also thanks to the birth of General Systems Theory (Ludwig Von Bertalanffy in 1950) and Cybernetics, that have led to the development of a Systemic Thinking.

In this new scenario, the **Constructivist Theory** (CT) was born. The implications that CT has on education are (Bodner, 1986):

- knowledge (especially physical and logico-mathematical) cannot be transferred from the mind of the teacher to the mind of the learner;
- the CT requires a shift from someone who 'teaches' to someone who tries to facilitate learning; a shift from teaching by imposition to teaching by negotiation;
- active students learn more than passive students (Herron, 1984) ;
- several advantages to the dialog between students and teacher;
- the importance of the two-directional flow of information between teachers and their students;
- students need to know that a problem exists before they are willing to accept an explanation.

CT has permitted a change in the educational model, moving from a rigid structure 'teacher and student' to a more flexible one.

Following the CT, was born an "holistic integrative perspective on learning that combines experience, perception, cognition and behavior"(Kolb, 1984): the **Experiential Learning** by Kolb, which sets experience as a source of learning and development.

Another contribution that allowed the educational field to move from the linear approach is the **Holistic Education** (HE): "the views central to HE are the result of a cultural 'paradigm shift' that began in 1960's" (Forbes, 1996). Forbes recognizes the HE like a movement born from the ecological crisis that has questioned the direction and the central values of the western world. The ecological crisis has revealed it is "not a respecter of political boundaries..the earth had to be seen as a whole (Gaia Hypothesis from L. Margulis and J. Lovelock)". Gaia Hypothesis has shown us that we need to look at the wholes to understand other things. This is the root of the 'Systems Approach' like some scientists came to call it, and it began to be seen as necessary for understanding even traditional disciplines:

"...seeing things as a system (or 'wholes' within 'wholes') was a better way to understand their traditionally reductionist disciplines as well as most other things. To understand anything is to understand its relationships to larger 'wholes'- the larger 'the whole' and the more extensive the relationships being understood, the truer the understanding"(Forbes, 1996).

The implications that the HE movement has on education are (Forbes, 1996):

- central value to relationship skills;
- the classroom is often seen as a community;
- learning means to assume responsibility, to question for oneself what is right: schools must be places where the relationships we want as adults exists for the students as much as possible;
- open, honest, respectful communication is the norm;
- differences between people are appreciated;
- interaction is based on mutual support and not on competition and hierarchy;
- common weal is the responsibility of each individual;
- emphasis on cooperation instead of competition;
- relationships between students, between teachers, and between students and teachers are seen as both a primary source of education and a topic of education;
- education is a process of discovery and uncovering;
- the teacher becomes less an authority who directs and controls and more a friend, a mentor, a facilitator, or an experiences travelling companion;
- importance of empathy in learning relationships.

CT and HE have demonstrated how Western Culture needs a paradigm shift even in educational field, in order to educate a new generation of people aware of current ecological problems and giving them the tools to face it and working in collaboration with the community and the environment and not against them.

1.3 Design discipline education

Thanks to the contributions of new cultural movements in the education field it was possible to encompass from the rigid structure of teacher-learner to a new period for the education system, where students play an active role and are required to become the protagonist of the process in constant evolution. One of the consequences of this shift is the transition from the teaching of theories to the teaching of methodologies.

A discipline where this approach is constantly applied is Design. As a process of creation and an applied science, the design lectures are based on the constant discussion between the students and the teacher, that in this case has the role to give them the methodological steps to follow in order to let the students create something new, expressing what they have in their minds.

The focus on a **methodology** is typical of the scientific-objective approach to design used in technical or polytechnic schools that differs from the creative-subjective approach, like Celaschi states: there are

"two educational traditions that have create profiles over the years of what we call 'designer', ...the second traditions (technical) has focused on learning a methodology and on the possibility to reiterate the process"(Celaschi et al., 2013).

Another important feature of design discipline that Celaschi stated is the multidisciplinary, or better the **trans-disciplinary**, as Piaget (1972) described "where several disciplines are not only interacting but are integrated in a whole where the traditional boundaries disappear". Moreover

"design as a discipline that lies midway between four different systems of knowledge: humanities and technology and engineer on one axis, and art/creativity and economics and management on an axis perpendicular" (Celaschi, 2008).

From these theories, Celaschi defines the profile of **Designer as Mediator** (that use trans-disciplinarity as a method) with the following features (Celaschi et al., 2013):

- escapes personalism and authority on the product;
- aims to build or consolidate the team and the mediated integration between different types of knowledge and different specialisms;
- discoverer of talents, builders of organizations and chains of skills;
- uses design tools not only to design products or services, but to define strategies, study situations and analyse opportunities;
- knowledge related to economics and management converge within, along with the humanistic knowledge of social sciences.

1.4 Systemic Design

The new theories that led to a systemic view of life, in the design discipline led to the birth of **Systemic Design (SD)**. SD theorized at Politecnico di Torino by Bistagnino aims to model production and energy systems after nature, since natural systems are efficient par excellence (Bistagnino, 2011). It emerges from the crisis in Design culture, because, like Papanek said in 1971, designers have a social responsibility towards the community since their ideas can create products that can be dangerous. Moreover, designers have a social responsibility also towards the environment because they are working with the flow of energy and matter, and with their decisions they move lots of resources around the world, most of the times just to meet strange wishes of someone that wants to follow the latest trend.

SD has changed the focus of design from the product to the production process that lies behind, based on the principle that "the output of a system is the input of another one" (Bistagnino, 2011). It aims to create a network among enterprises working on the stream of energy and matter that flows from a production process to another one involving all the natural kingdoms, with the goal to tend to zero emissions, in a deeply connection with the local territory. It talks about 'open living systems': "Schrodinger defined the living systems open in the sense that they continually draw upon external sources of energy and maintain a stable state of low entropy that is far from thermodynamic equilibrium" (Barbero, 2012).

2. Case Study_ 'Open systems' academic lab

The case study used to sustain the thesis of this paper is the academic lab 'Open Systems' of the Italian Master of Science Systemic Design 'Aurelio Peccei' of Politecnico di Torino, born in the academic year 2003-04 as a course in the MSc 'design of eco-products'. It lasts one semester and it is composed by four courses that work together with the aim to train students in the field of Systemic Design.

The principal course *Systemic Design* leads students to experience the design of relations creating a system, starting from the analysis of a specific production process, in order to change the current production model to a systemic one that tends to zero emissions. The other three courses give support for the comprehension of the approach and the implementation of the project, focusing on specific parts thanks to the contributions of other disciplines: economy, engineering and humanities.

2.1 Systemic design course

2.2 Structure and content

The course in *Systemic Design* trains students in the creation of a system, giving 'only' some steps to follow in order to create a systemic project. The students are divided in groups (that they have to create by themselves) and should come to lessons twice a week in order to talk with the teachers about the progress of the project. The approach used is 'learning by doing': for each step each group has to create several visual maps in order to "organize the quality of information in cognitive structure" (Barbero, 2016), allowing them to show to the other students what they are doing in a clear way and to receive feedbacks from both the teachers and the students. In this way, they become aware week after week of their work and they understand by themselves what they have to change in order to reach a better result.

At the beginning of the course a specific territory is assigned to the students where they have to focus its attention on a specific micro-small production activity. In the first weeks they start with the analysis of the current situation and production model, later they have to develop it into a systemic production model, creating the macro system of the territory.

In this case the role of the teacher is to:

- give a topic to work on;
- give the steps of the methodology to follow;
- discuss with them twice a week.

The peculiarity of this course is that the teacher doesn't tell the students which adjustments they have to do, but, with a free talk on general aspects, he/she lets them focus on some aspects that they didn't have yet considered. In this way, they become aware of new aspects and learn at a deeper level, without learning by heart some contents just to pass an exam. For the final exam, they have to demonstrate how much they have become aware of the concepts they analyzed and auto-evaluate their work.

The structure and the contents are represented in the next paragraph with the visual maps created by the students of the 2015-2016 academic year (Battistoni et al., 2016) and 2013-2014 academic year. Other examples can be seen in Bistagnino, 2011 and Bistagnino, 2016.

2.3 Principal steps

- 1° step: Holistic Diagnosis of the territory, with desk and field research

After the assignment of a specific territory to work on, the students are asked to start with the analysis of it, with a holistic diagnosis (HD). In this step they have to analyze all the specific characteristics with a field and a desk research (Barbero, 2016). HD is important to outline the context in which they have to work, focusing the attention on the local material culture and the natural resources.

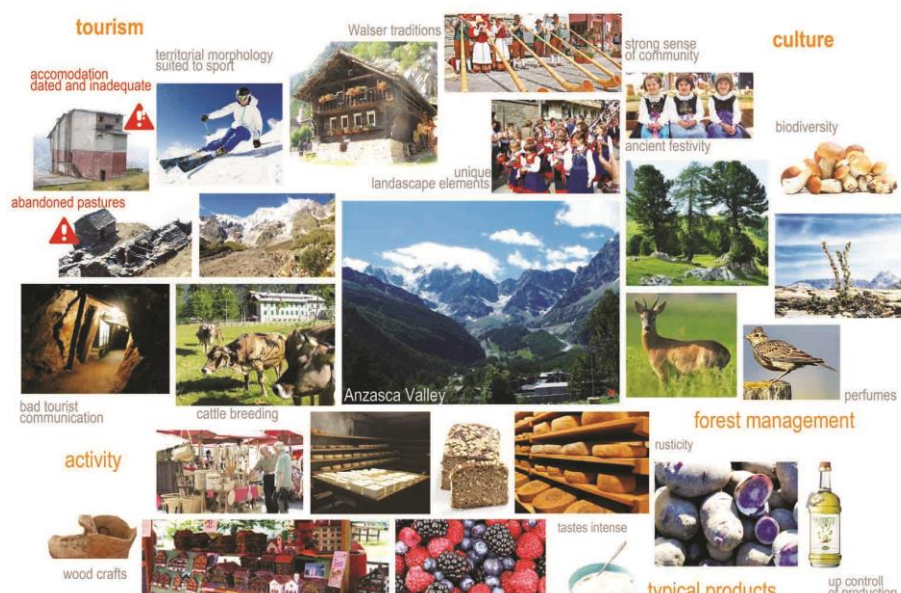


Fig. 1 - Holistic Diagnosis of Anzasca Valley (2015-16 academic year)

- 2° step: Analysis of the current situation of a production model with desk and field research

Concluded the analysis of the territory, the students have to start with the HD of a single production process of a micro-small enterprise located in the specific territory, examining the current production model. The output of this step is the first creation of a visual map that becomes everyday more complex.

In this analysis the team of teachers first suggests them to do a field research having a look on the production activity, talking with the employees and collecting data. They should focus on the different steps of the production process and define the quantity and quality of the flow of resources that enter in the process and goes out. A deeper analysis on where these resources come from and go let them understanding which are the territories that this production model involves.

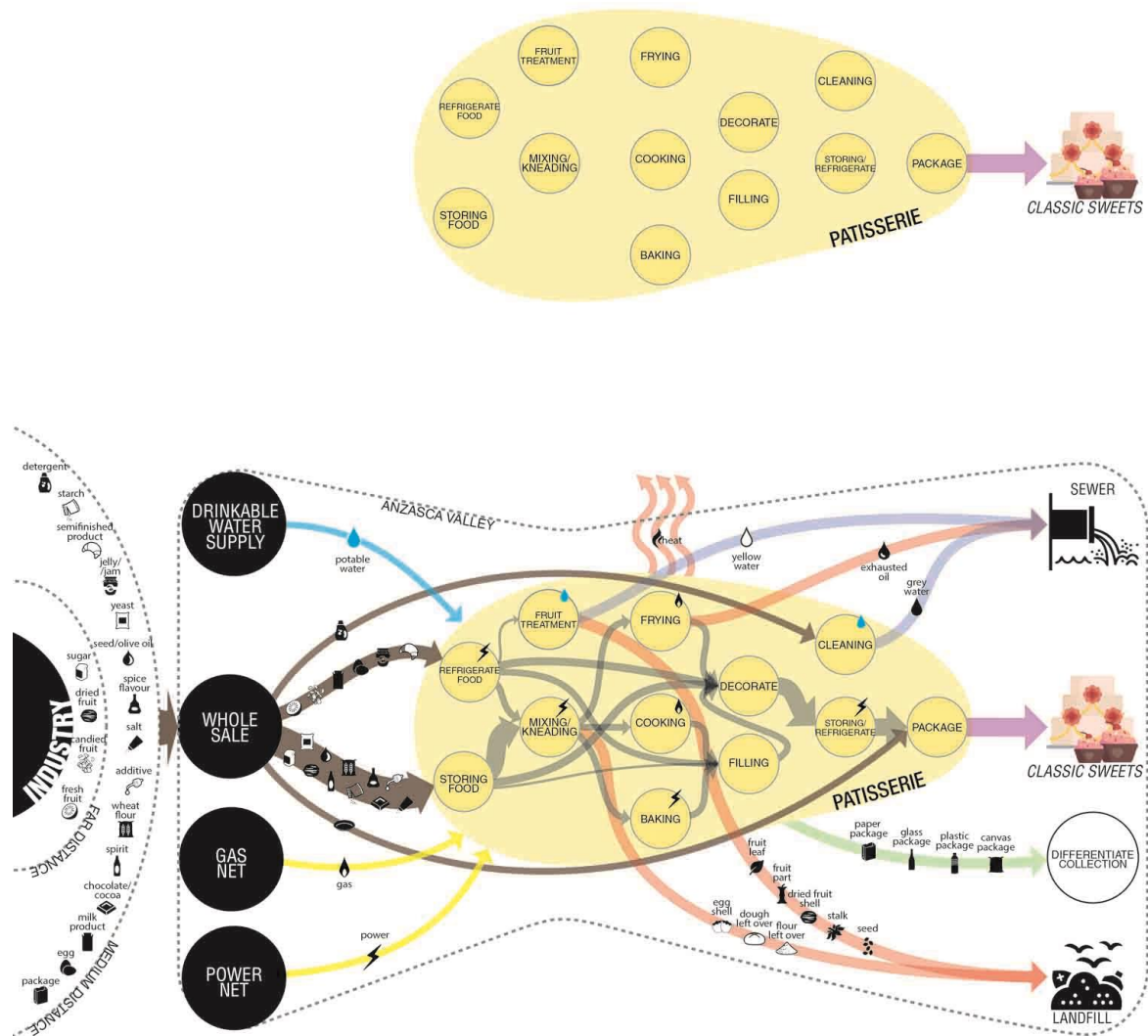


Fig. 2 - analysis of the current production model of a patisserie in two steps of specification (2015-16 academic year)

- 3° step: identification of problems of the production model with desk and field research

After this phase they are able to understand (as demonstrated by the visual map that they create-fig. 4) that a production process involves a flow of matter and energy and what enters in one ('input') comes out ('output') in another one, changing its quality. In this way they are able to identify the current problems, relying also on desk research, studying literature and current researches.

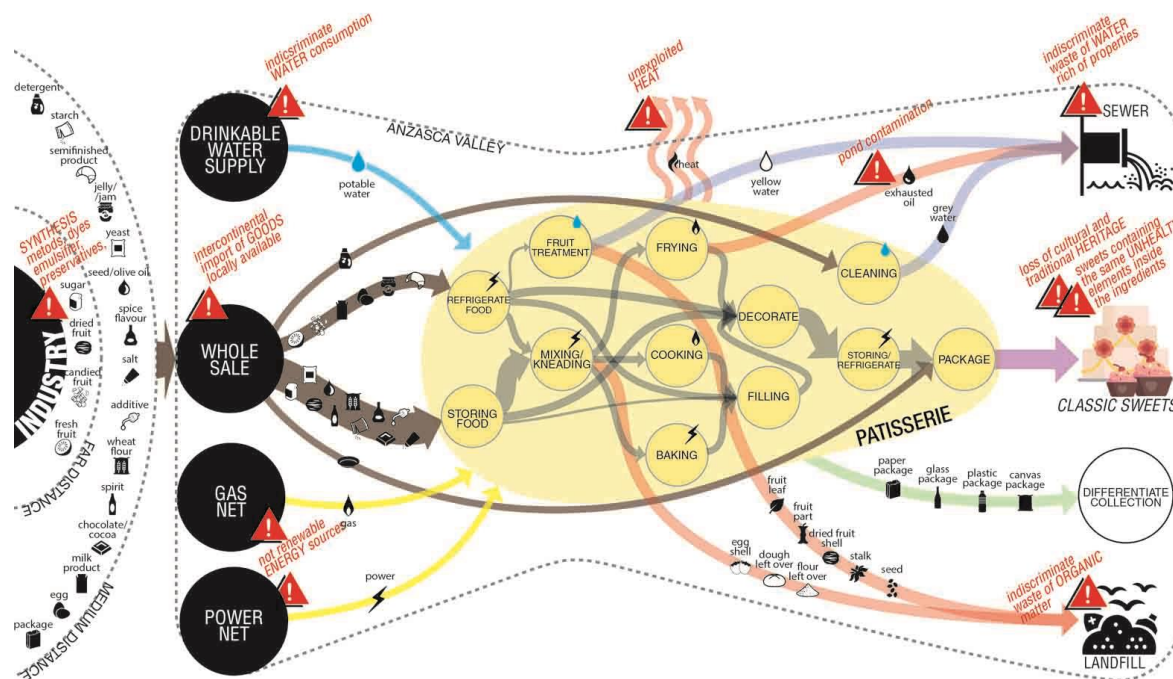


Fig. 3 - analysis of the current problems of a patisserie (2015-16 academic year)

- 4° step: from problem to opportunity

The previous analysis allows the students to understand that things that go out from a process are not waste but resources with a value, that the current production model is throwing away in the landfill (considering matter), in the sewer (considering water) and burning or dissipating (considering energy). Indeed in Nature nothing is waste, everything is used, maybe in other food chains or for another kingdom. If there are problems in the inputs, they will be present also in the outputs. With this approach problems became leverages for change and are the kick-off point to start hypothesis on what is possible to do to change the current production model.

- 5° step: definition of the new systemic production model: the open system

At this point students are able to transform the current production model into a 'systemic' one that considers the quality of the matter and energy used in the process, improving the value of the resources inside the process or outside it. Following this approach, students finally demonstrate to be able to construct a system where each production processes is linked to the others. In this way new potential activities (not present today) that can use these resources are generated (following the autopoietic property of a living system).

The system presents boundaries (in this case the territory in which it is situated) but it is open: the system created is very similar to a living cell.



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Moreover the course, year after year, is questioning its educational model thanks also to the increasing number of students.



Fig. 5 - active role of the students in the construction of the system

- 6° step: definition of the relations in the whole territory, the Macro System of the Systems

Generating relations between the different systems that they have previously defined, the students demonstrate to be able to create the *Macro System of Systems* where each production activity of the territory analyzed in the HD is involved.

As Bistagnino states

"the Macro System of Systems is a conceptual schematic of the probable reality. This leads naturally to a configuration of cooperation between the various actors in which, as for credit, each one comes in as an active part of this heritage, like all the others. This is the advantage that everyone adds to the whole network, as well as vice versa. The main market of reference becomes the local one and is also the place where the interrelationships of the various players become concrete" (Bistagnino, 2016).

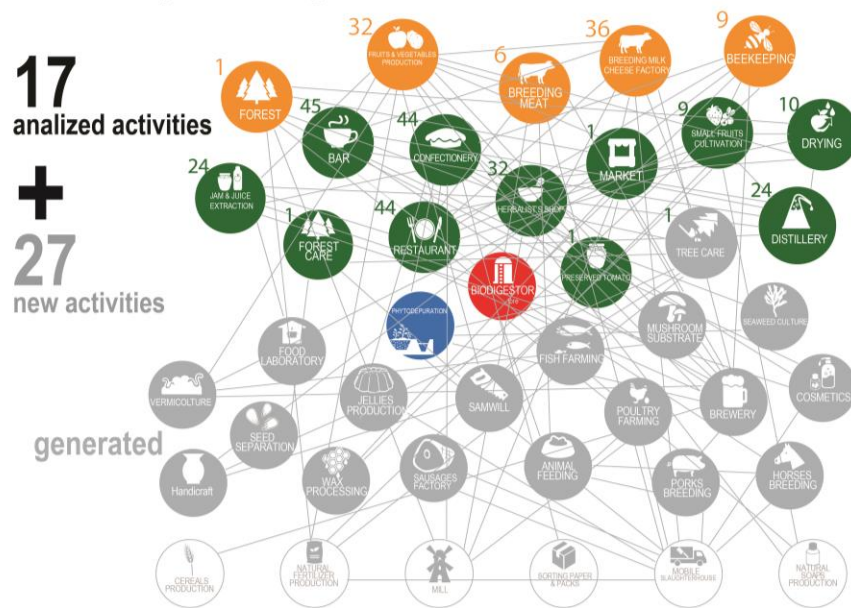


Fig. 6 - the 'Macro system of systems' of Anzasca Valley (2015-16 academic year)

- 7° step: definition of the outcomes generated on the whole territory analyzed

With the creation of the *Macro System of Systems* students are able to understand the changes that the cultural shift from a linear to a systemic approach can create also on economy, corporate model, management of companies, distribution, sale, communication, marketing, currency, packaging, until two general topics like tourism and the society, defining a new cultural paradigm (see Battistoni et al., 2016).

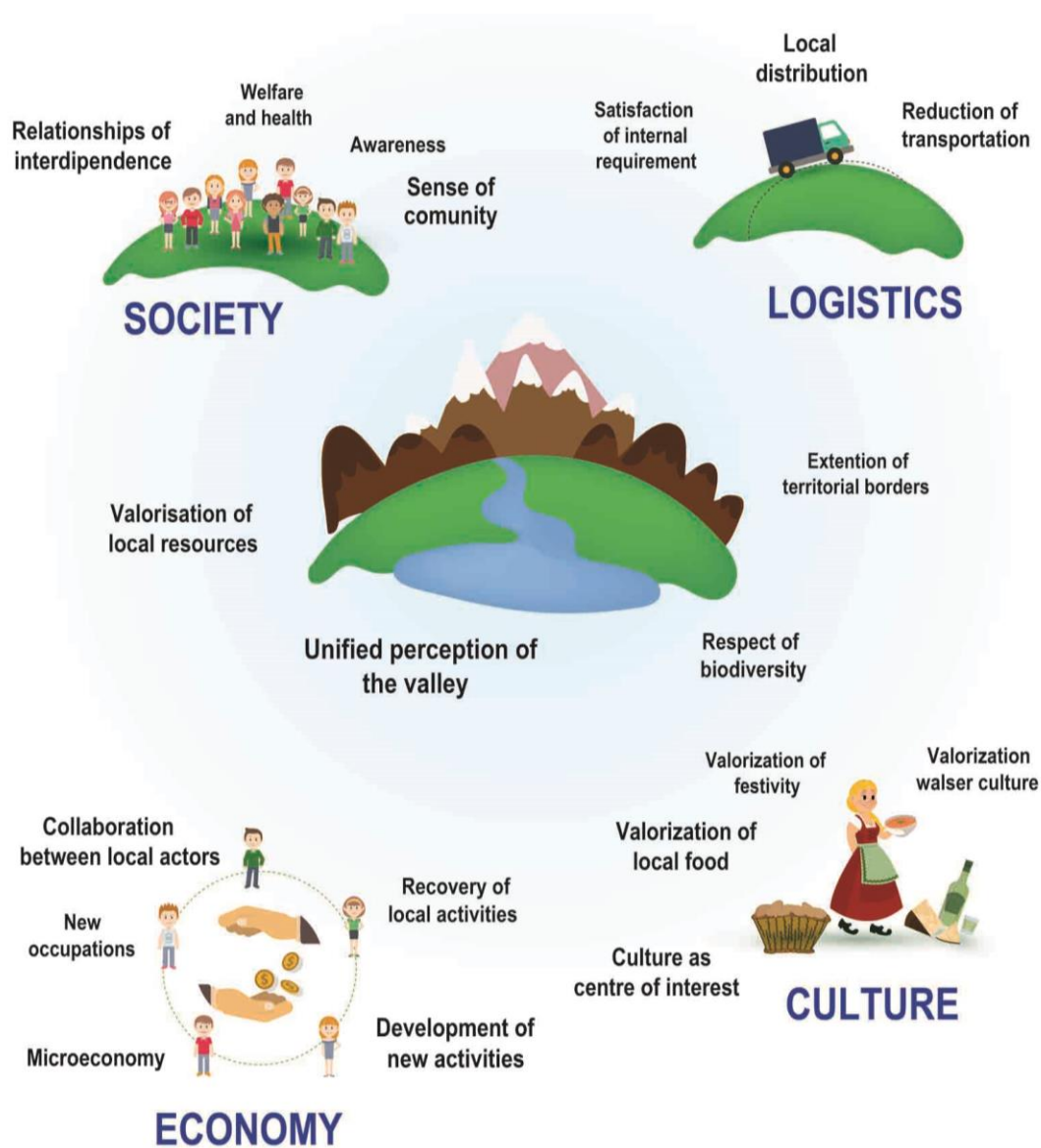


Fig. 7 - definition of the outcomes in Anzasca Valley (2015-16 academic year)

Another example of the work done by the students is represented in fig. 8 and the principal steps of the methodology are represented in fig. 9

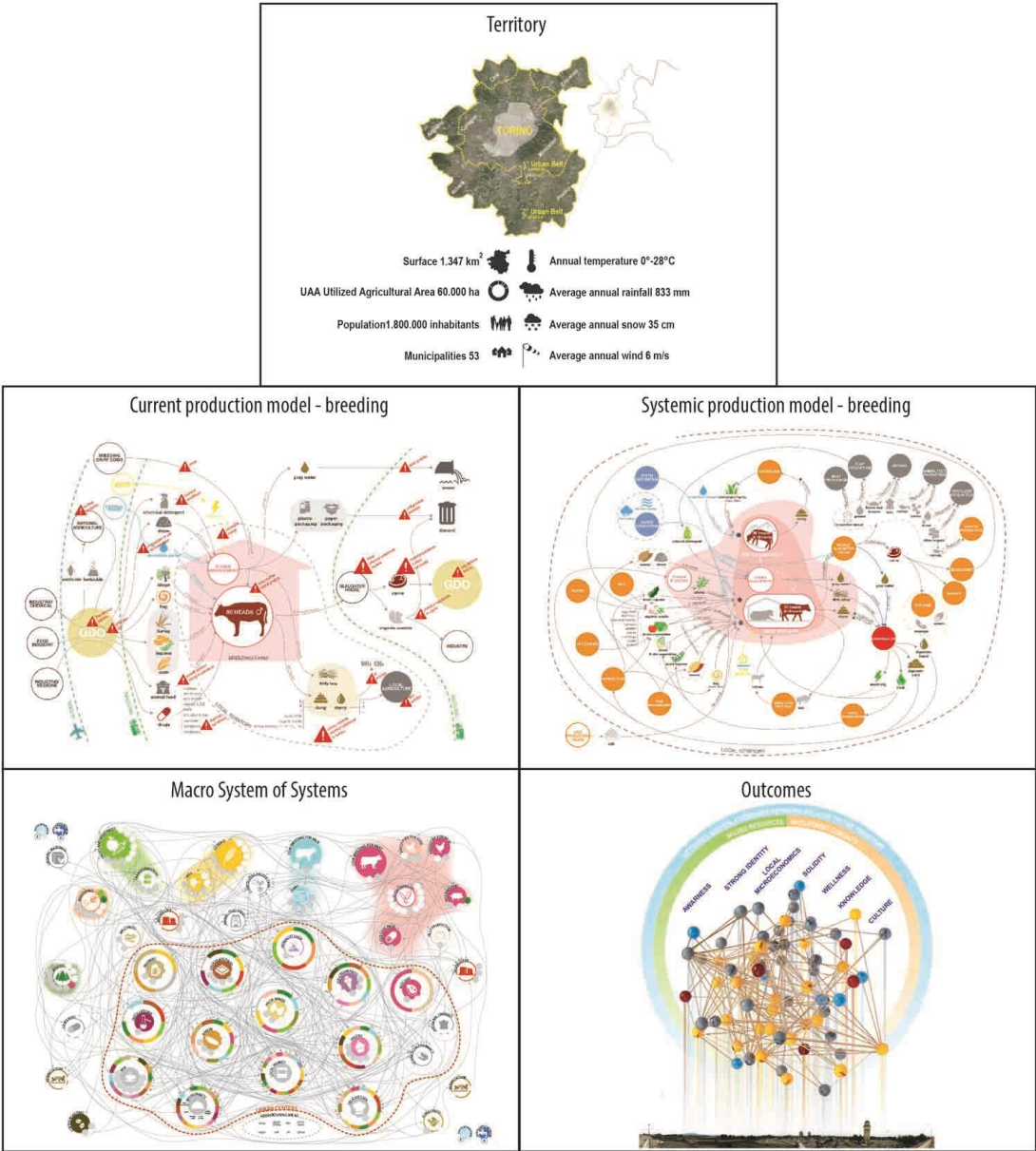


Fig. 8 - work done by the students of the 2013-14 academic year for Torino 1° and 2° belt with the example of the activity of breeding

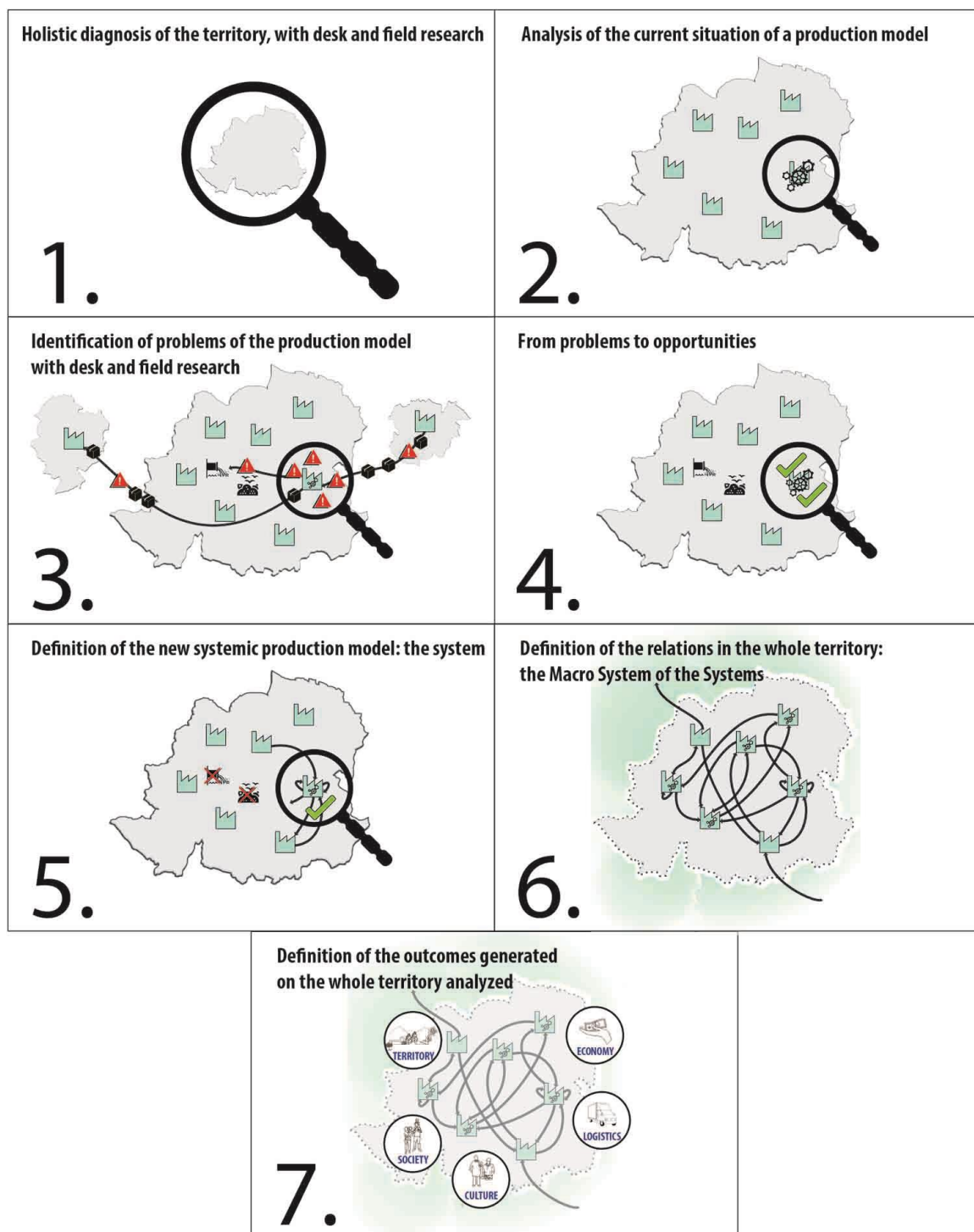


Fig. 9 - principal steps defined year after year

2.4 Relationship with other disciplines

Three other courses are offered in the 'Open Systems' lab, in order to give the students the tools to implement the project and understand the systemic approach:

- "Economic management of projects" (Economics): with an economist as a teacher, it gives the students the tools to realize a economic assessment in order to quantify the economic outcomes of the project, giving economic values to the new resources;
- "Procedures for environmental sustainability" (Engineering): taken by an engineer, it helps the students to understand the technical aspects of the project;
- "Theory and history of open systems" (Humanities): it makes the students aware of the systemic cultures (systems thinking) through the study of the cultural background.

These courses, taught in a more traditional way, in the first weeks give the students the theoretical background, then contribute to the definition of the systemic project.

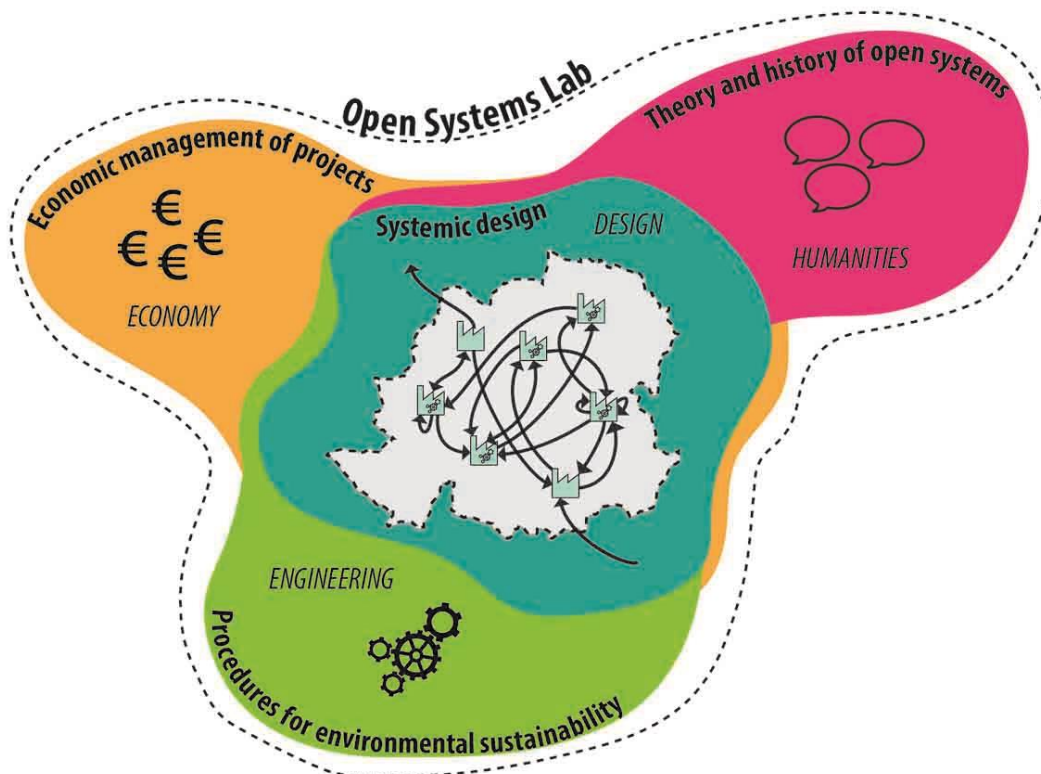


Fig. 10 - relationships between the four courses of the lab

3. Results_The systemic education model

From the description of the academic lab 'Open Systems', it is possible to understand how, especially the *Systemic Design* course, is experiencing a new model of education.

We can summarize the characteristics of this model in:

- based on team working between students and after between groups (students have an active role and are called to act like a community);
- different disciplines cope together for the development of the project;

- improved year by year to adapt to new challenges;
- boss less structure;
- generation of visual maps, always in progress;
- relation with a specific context of reference;
- management of an increasingly complex project;
- from general to particular, from particular to general.

It is possible to state that it is aligning with the characteristics of the main topic discussed, an open system, because we can define as the particular features of a natural system, e.g. the living cell (Capra, 1996):

- composed of different single parts which are related to each others;
- the parts cope together for a common purpose;
- resilient;
- self-regulating: it produces its own pattern of behaviour over time;
- self-generating: it produces what it needs;
- open: the system interacts with the other systems and the environment, exchanging matter and energy;
- complex.

The model, in terms of structure, content and way of teaching, was set based on the different experiences had by the teachers and the analysis of the results achieved by the students, year after year.

From the evolution of the work of the students during the semester (shown in paragraph 2.1.2) is possible to state that the method used has the potential to increase the ecological awareness on their actions and choices (it is linked to 'Systemic Education' discussed by Peruccio, 2016). Seeing the class as a community, the main goal of the lab is indeed the teaching of 'awareness' (Bistagnino, 2016) without imposing theories, but leaving the students understanding the problems of the current production model and giving them the tools to reach a full sustainability (environment, social, economic) in the production model that can also permits a sustainable development for the entire territory analyzed.

4. Conclusion

The analysis of the academic lab has permitted to set the features of a different educational model (a systemic educational model) that differs from the Systemic Education just mentioned by Supovitz in 2005. This model is perfectly in line with the two recent educational movements, the Constructivist Theory and the Holistic Education: they have demonstrated how Western Culture needs a paradigm shift even in educational field, in order to educate a new generation of people aware of current ecological problems and giving them the tools to face it and work in collaboration with the community and the environment and not against them. The lab results to be able to train a new generation of Designers, Systemic Designers "able to plan virtuous relationships between people and productive activities generating positive effects on social and environmental scale"(Bistagnino, 2016). Like Bistagnino stated "Teaching itself is transformed because it's necessary to shift it from the study of individual disciplines into a learning in which they talk each other" (Bistagnino, 2016). In this academic lab the collaboration between different disciplines is realized.

It is possible to demonstrate the success of the model by:

- the increased number of students enrolled over the years (from about 10 students in 2003 to an average of 90 from the academic year 2010/2011);
- the progressive application of the specific characteristics of this model to the other labs of the Master of Science 'Systemic design,Aurelio Peccei': from 'Product Components' to 'Innovation' and 'Virtual Design';
- the satisfaction of the students: about 80% of the students said in 2015 that they are satisfied from the entire Master of Science (data from Alma Laurea) so, being the lab the one that characterizes the entire MSc, it is possible to consider this data important also for the success of the lab;
- the grade of the employment of the students: about 80% of the students said in 2015 that they are employed after the entire Master of Science (data from Alma Laurea) so, being the lab the one that characterizes the entire MSc, it is possible to consider this data important also for the success of the lab;
- the interest shown by public local institutions that every year suggest a topic to work on (e.g. municipality of Giaveno, Torino, Macugnaga, Sestriere,...)
- the increased number of students that did a thesis in Systemic Design: 3 in 2004, 15 in 2010, 29 in 2015;
- the increased importance at national level:
 - the Master of Science in 2016 has changed the name from 'Ecodesign' to 'Systemic design-Aurelio Peccei' (the importance was recognized by the Club of Rome, Kyoto Club and Zeri foundation/Blue Economy);
 - about 30% of students comes from other regions of Italy (10% in 2004, 44% in 2016) ;
- the increased importance at international level:
 - about 30% of students comes from foreign countries (15% in 2004, 25% in 2016).

A limit of the model can be recognized in the strong dependency of its success from the ability of the teacher to shift his/her skills from Explain and Evaluate to, as stated by the 5-step model by BSCS, Engage, Explore, Explain, Elaborate, and Evaluate (Kolb, 1984). In this way is possible to let the students constructing knowledge and awareness on the topic analyzed.

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